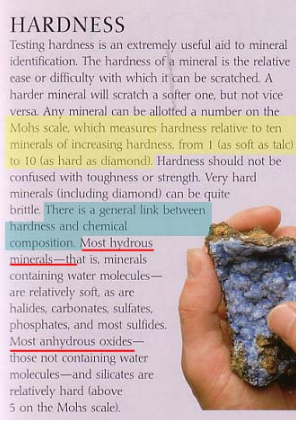
Physical Mineralogy

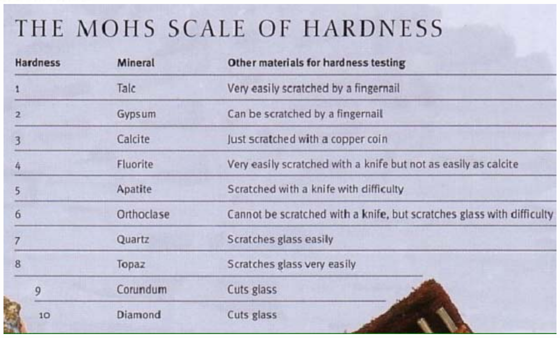
1. Properties depending upon light
2. Crystal Habit (of crystal form)
3. Hardness and Tenacity
4. Cleavage, parting and fracture
5. Density
6. Magnetic, and electrical properties

- Hardness ➔ the resistance of the surface of the crystal to a scratch
- The hardness scale ➔ Mohs scale ➔ 1-10
- The hardest one is diamond



HARDNESS

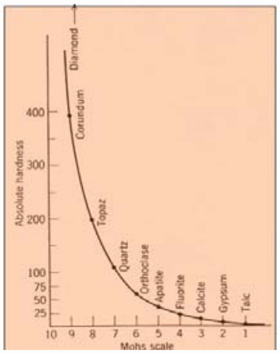
Testing hardness is an extremely useful aid to mineral identification. The hardness of a mineral is the relative ease or difficulty with which it can be scratched. A harder mineral will scratch a softer one, but not vice versa. Any mineral can be allotted a number on the Mohs scale, which measures hardness relative to ten minerals of increasing hardness, from 1 (as soft as talc) to 10 (as hard as diamond). Hardness should not be confused with toughness or strength. Very hard minerals (including diamond) can be quite brittle. There is a general link between hardness and chemical composition. Most hydrous minerals—that is, minerals containing water molecules—are relatively soft, as are halides, carbonates, sulfates, phosphates, and most sulfides. Most anhydrous oxides—those not containing water molecules—and silicates are relatively hard (above 5 on the Mohs scale).



THE MOHS SCALE OF HARDNESS

Hardness	Mineral	Other materials for hardness testing
1	Talc	Very easily scratched by a fingernail
2	Gypsum	Can be scratched by a fingernail
3	Calcite	Just scratched with a copper coin
4	Fluorite	Very easily scratched with a knife but not as easily as calcite
5	Apatite	Scratched with a knife with difficulty
6	Orthoclase	Cannot be scratched with a knife, but scratches glass with difficulty
7	Quartz	Scratches glass easily
8	Topaz	Scratches glass very easily
9	Corundum	Cuts glass
10	Diamond	Cuts glass

Mohs scale vs absolute hardness



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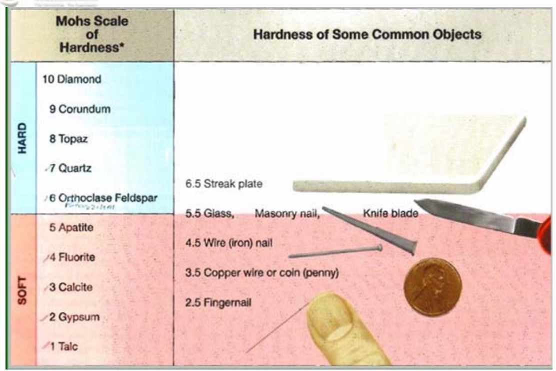

	Mohs Scale of Hardness*
HARD	10 Diamond
	9 Corundum
	8 Topaz
	7 Quartz
	6 Orthoclase Feldspar
SOFT	5 Apatite
	4 Fluorite
	3 Calcite
	2 Gypsum
	1 Talc

Hardness of Some Common Objects

6.5 Streak plate

5.5 Glass, Masonry nail, Knife blade

4.5 Wire (iron) nail

3.5 Copper wire or coin (penny)

2.5 Fingernail

Tenacity

Tenacity is the resistance that a mineral offers to breaking, crushing, bending, cutting, or other acts of destruction.

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- Malleable : can be formed, flaked without need to be broken.
- Sectile: can be shaved with metallic material or knife.
- Flexible: can be modified (ex. fold) and still in the last mode when there is no force anymore.
- Ductile: can be modified without any fracture.
- Brittle: can not be modified, easy to broke or fracture.
- Elastic: can be modified, full, fold and go back to original form when there is no more force.

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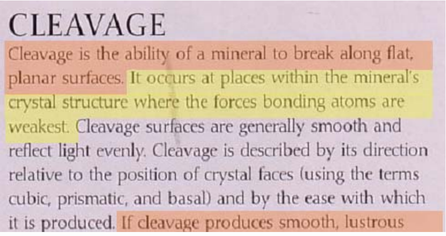
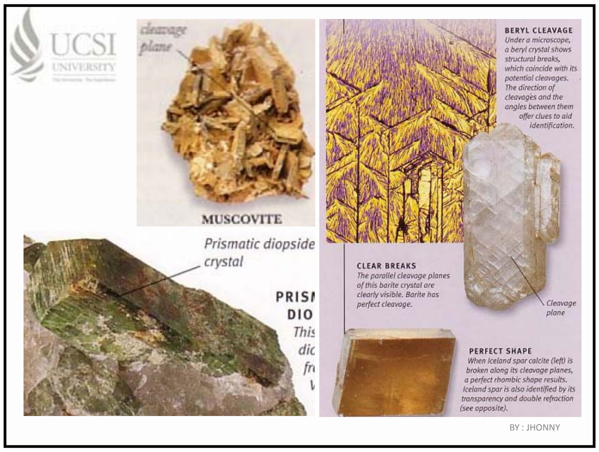
4. Cleavage, parting and fracture



CLEAVAGE

Cleavage is the ability of a mineral to break along flat, planar surfaces. It occurs at places within the mineral's crystal structure where the forces bonding atoms are weakest. Cleavage surfaces are generally smooth and reflect light evenly. Cleavage is described by its direction relative to the position of crystal faces (using the terms cubic, prismatic, and basal) and by the ease with which it is produced. If cleavage produces smooth, lustrous



BERYL CLEAVAGE
Under a microscope, a beryl crystal shows structural breaks, which coincide with its potential cleavages. The direction of cleavages and the angles between them offer clues to aid identification.

CLEAR BREAKS
The parallel cleavage planes of this barite crystal are clearly visible. Barite has perfect cleavage.

PERFECT SHAPE
When Iceland spar calcite (left) is broken along its cleavage planes, a perfect rhombic shape results. Iceland spar is also identified by its transparency and double refraction (see opposite).

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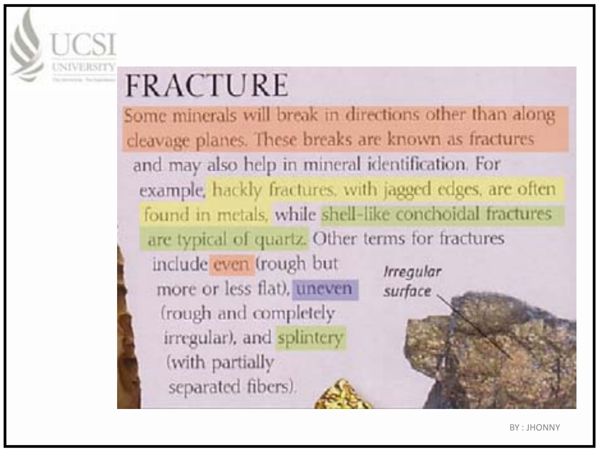
UCSI UNIVERSITY
Irregular surface

FRACTURE

Some minerals will break in directions other than along cleavage planes. These breaks are known as fractures and may also help in mineral identification. For example, hackly fractures, with jagged edges, are often found in metals, while shell-like conchoidal fractures are typical of quartz. Other terms for fractures include even (rough but more or less flat), uneven (rough and completely irregular), and splintery (with partially separated fibers).

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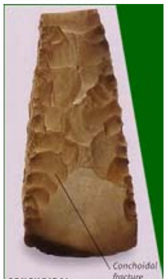
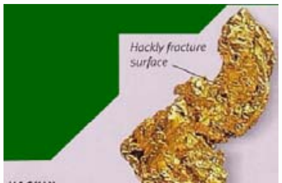
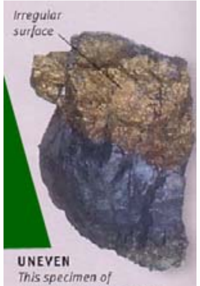


CONCHOIDAL
This Bronze Age chert ax shows conchoidal fracture, with cavities shaped like a bivalve seashell.

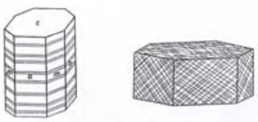


HACKLY
This gold nugget shows hackly fracture, involving sharp edges and jagged points.



UNEVEN
This specimen of chalcopyrite shows uneven fracture. Its broken surface is rough and irregular, with no pattern evident.

Parting



Parting is characteristically similar to cleavage. It is easily confused with cleavage, and is often present or hibit any cleavage. arting:

- Two se ward the center of a cr ing the crystal interio , smooth plane.
- Twin crystals that separated from one another, leaving a flat, smooth plane.

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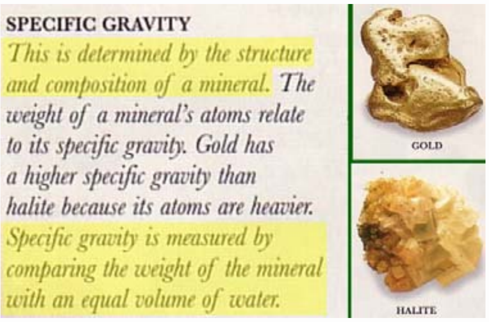
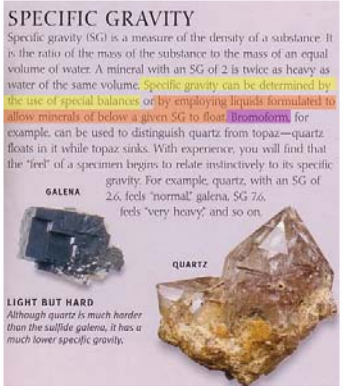
5. Density



SPECIFIC GRAVITY

This is determined by the structure and composition of a mineral. The weight of a mineral's atoms relate to its specific gravity. Gold has a higher specific gravity than halite because its atoms are heavier. Specific gravity is measured by comparing the weight of the mineral with an equal volume of water.

GOLD
HALITE



SPECIFIC GRAVITY

Specific gravity (SG) is a measure of the density of a substance. It is the ratio of the mass of the substance to the mass of an equal volume of water. A mineral with an SG of 2 is twice as heavy as water of the same volume. Specific gravity can be determined by the use of special balances or by employing liquids formulated to allow minerals of below a given SG to float. Bromoform, for example, can be used to distinguish quartz from topaz—quartz floats in it while topaz sinks. With experience, you will find that the "feel" of a specimen begins to relate instinctively to its specific gravity. For example, quartz, with an SG of 2.6, feels "normal," galena, SG 7.6, feels "very heavy," and so on.

LIGHT BUT HARD

Although quartz is much harder than the sulfide galena, it has a much lower specific gravity.

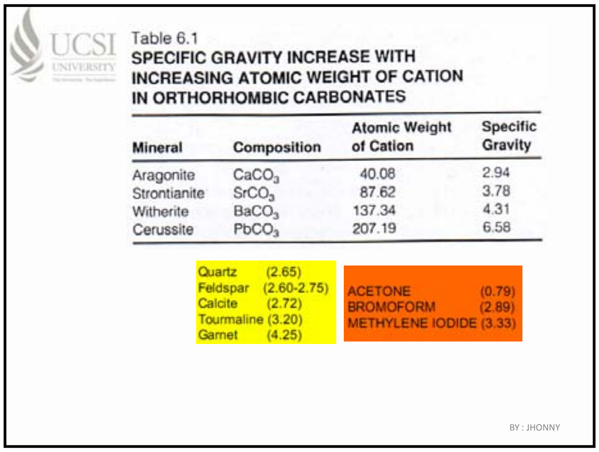


Table 6.1

SPECIFIC GRAVITY INCREASE WITH INCREASING ATOMIC WEIGHT OF CATION IN ORTHORHOMBIC CARBONATES

Mineral	Composition	Atomic Weight of Cation	Specific Gravity
Aragonite	$CaCO_3$	40.08	2.94
Strontianite	$SrCO_3$	87.62	3.78
Witherite	$BaCO_3$	137.34	4.31
Cerussite	$PbCO_3$	207.19	6.58

Quartz	(2.65)
Feldspar	(2.60-2.75)
Calcite	(2.72)
Tourmaline	(3.20)
Garnet	(4.25)

ACETONE	(0.79)
BROMOFORM	(2.89)
METHYLENE IODIDE	(3.33)

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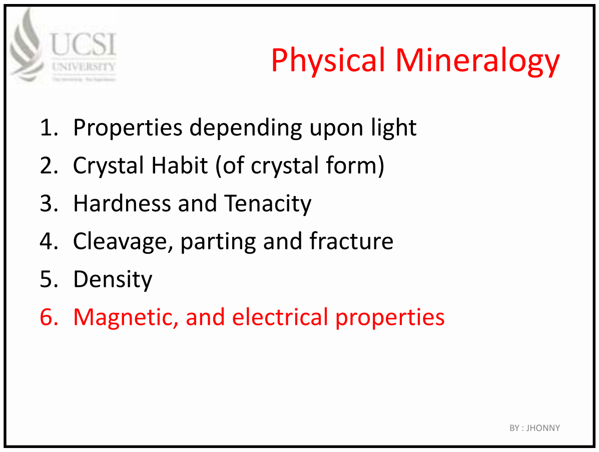

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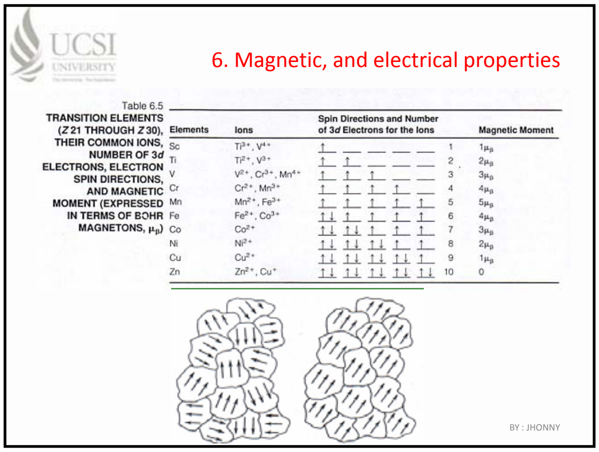

6. Magnetic, and electrical properties

Table 6.5

TRANSITION ELEMENTS (Z 21 THROUGH Z 30), THEIR COMMON IONS, NUMBER OF 3d ELECTRONS, ELECTRON SPIN DIRECTIONS, AND MAGNETIC MOMENT (EXPRESSED IN TERMS OF BOHR MAGNETONS, μ_β)

Elements	Ions	Spin Directions and Number of 3d Electrons for the Ions						Magnetic Moment
Sc	Ti^{3+}, V^{4+}	↑					1	$1\mu_\beta$
Ti	Ti^{2+}, V^{3+}	↑	↑				2	$2\mu_\beta$
V	V^{2+}, Cr^{3+}, Mn^{4+}	↑	↑	↑			3	$3\mu_\beta$
Cr	Cr^{2+}, Mn^{3+}	↑	↑	↑	↑		4	$4\mu_\beta$
Mn	Mn^{2+}, Fe^{3+}	↑	↑	↑	↑	↑	5	$5\mu_\beta$
Fe	Fe^{2+}, Co^{3+}	↑↓	↑	↑	↑	↑	6	$4\mu_\beta$
Co	Co^{2+}	↑↓	↑↓	↑	↑	↑	7	$3\mu_\beta$
Ni	Ni^{2+}	↑↓	↑↓	↑↓	↑	↑	8	$2\mu_\beta$
Cu	Cu^{2+}	↑↓	↑↓	↑↓	↑↓	↑	9	$1\mu_\beta$
Zn	Zn^{2+}, Cu^{+}	↑↓	↑↓	↑↓	↑↓	↑↓	10	0

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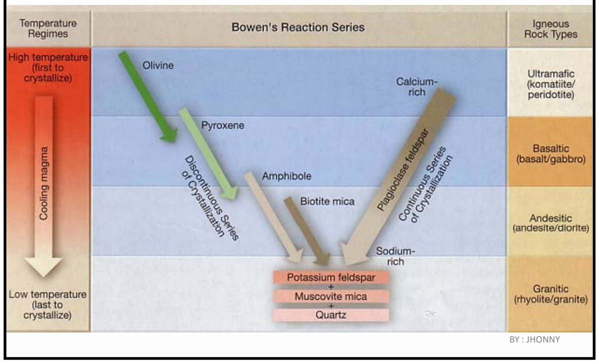
What is the rule of mineral identification on PE?

Thank you very much
To be continue…


Temperature Regimes
Bowen's Reaction Series
Igneous Rock Types
High temperature (first to crystallize)
Cooling magma
Low temperature (last to crystallize)
Olivine
Pyroxene
Amphibole
Biotite mica
Discontinuous Series of Crystallization
Calcium-rich
Plagioclase feldspar
Continuous Series of Crystallization
Sodium-rich
Potassium feldspar
+
Muscovite mica
+
Quartz
Ultramafic (komatiite/ peridotite)
Basaltic (basalt/gabbro)
Andesitic (andesite/diorite)
Granitic (rhyolite/granite)